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ac-dc power supplies

BEHLMAN-INVAR ELECTRONICS CORP.
1723 CLOVERFIELD BLVD.
SANTA MONICA, CALIF.

REPRESENTATIVES IN ALL PRINCIPAL CITIES AND CANADA

EX 3-9611 • UP 0-9346 • TWX SMON-7098

Ser. # 2049

MANUAL

OPERATIONAL - MAINTENANCE

MODELS: TP-2, -5, -10, -15
and TP-30 SERIES

Publication No.: 1001

NOTICE:

The information contained herein is for the sole purpose of providing the data used in operating and maintaining the above-captioned power supplies and may not be used for any other purpose or reproduced in any form, either in whole or in part, without the written consent of Behlman-Invar Electronics Corp.

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SECTION I
INTRODUCTION AND DESCRIPTION

1-1. GENERAL.

Behlman-Invar Electronics Corporation, who have pioneered many of the more important advancements in the field of transistorized power supplies, are pleased to submit this instruction manual for the Model TPA Series power supply units, TP-2, -5, -10, -15 and TP-30.

These models are precision transistorized power supplies which operate from 105/125 volts ac at 55/65 cps line voltage, and deliver a precisely regulated dc output. (See Paragraph 1-7, Electrical Specifications.) These units may be used in the laboratory or incorporated in other electronic equipment as a source of high quality, fully regulated dc power.

1-2. PURPOSE.

To provide power supplies under design criteria conforming to the latest state of the art.

To provide an operational and instruction manual containing complete information for assistance when using the units.

1-3. WARRANTY.

Seller warrants the end product of its design and construction to be free from defects in material and workmanship. Any component parts other than vacuum tubes, fuses, blower motors, indicating lamps, and other indicating devices (except as warranties on these items are passed on to the seller by its suppliers), which become defective during the first year after shipment will be replaced free of charge by the seller, provided that the instrument is returned with transportation charges prepaid by the original purchaser and that our examination discloses to our satisfaction that the instrument is defective, but if the apparatus is installed, or its installation supervised, by the seller, said year

shall run from the completion of the installation, provided that same is not unreasonably delayed by the buyer.

The condition of any tests shall be mutually agreed upon, and the seller shall be notified, and may be represented at, all tests that may be made. The liability of the seller to the buyer (except as to title) arising out of the supplying of the said apparatus, or its use, whether on warrant, contract, or otherwise, shall not in any case exceed the cost of correcting defects in the apparatus as herein provided, and upon the expiration of said year all such liability shall terminate.

The foregoing shall constitute the sole remedy of the buyer, and the sole liability of the seller.

1-4. PREPARATION FOR USE AND RESHIPMENT.

Unpack the instrument with care and inspect it for any damage which it may have incurred in transit. If there is any damage, or if the unit fails to operate properly in accordance to instructions (See Paragraph 2-7), a claim should be filed with the carrier, with a copy of the Claim Agent's report being forwarded to Behlman-Invar Electronics Corporation.

NOTE:

DO NOT RETURN THE INSTRUMENT TO THE FACTORY WITHOUT PRIOR AUTHORIZATION FROM BEHLMAN-INVAR ELECTRONICS CORPORATION.

On packaging for reshipment use adequate shock-absorbent material within the carton to prevent the instrument's sharp corners from protruding which would result in unit damage.

1-5. QUALITY CONTROL AND INSPECTION.

Behlman-Invar Electronics Corporation functions under a company-wide quality assurance program which insures that our customer receives equipment manufactured to the most exacting standards. This quality assurance system is based on the best commercial practices augmented by policies and procedures required under MIL Q-9158.

1-6. SAFETY NOTES.

WARNING

Operation of the Behlman-Invar power supplies involves the use of high voltage. Use EXTREME CAUTION when any internal adjustments or tests are being performed.

CAUTION

When remote sensing is not used, VERIFY that the REMOTE SENSE shorting jumpers are correspondingly installed on the minus and plus remote sense terminals located on the chassis rear to avoid damaging the unit. (See Schematic, Figure A-1.)

1-7. ELECTRICAL SPECIFICATIONS.

The following tabulation lists the electrical characteristics for the TP Series power supplies (5 each), Models TP-2, -5, -10, -15 and TP-30.

	Output dc		Regulation		Ripple	Output Z		Transients	
Model	E (v dc)	I (amps)	Line	no load to full load	mV rms max.	ohms dc	ohms 100 kc	±10% line	Recovery time no load to full load μsec. max.
TP-2	0-32	2	10	5	0.6	0.002	0.1	None	20
TP-5	0-32	5	10	5	0.5	0.001	0.1	None	30
TP-10	0-32	10	10	5	0.5	0.0005	0.1	None	50
TP-15	0-32	15	10	5	0.5	0.0003	0.1	None	75
TP-30	0-36	30	10	5	1.0	0.0002	0.1	None	100

TABLE 1-1.

Input Line Voltage
For All 5 Models: 105/125v ac at 55/65 cps, single phase.

Remote Sensing: Remote sensing is provided so that the selected output potential is maintained across a remote load despite a nominal line drop (due to their length) in the interconnecting cables.

Short Circuit Protection: Unit is capable of being shorted continuously without damage. Turning on the unit while the output or remote load is shorted causes no damage, and when the short is removed the voltage and current return to preset values.

1-8. ENVIRONMENTAL SPECIFICATIONS.

F1: Fuse, 2 amp, located on the rear of the chassis and inserted in the ac input to the supply.

F2: Fuse, 2 amp, located on the rear of the chassis and inserted in the raw dc output of the supply.

Operating Temperature: 0° to 50° C.

1-9. MECHANICAL SPECIFICATIONS.

Model	Width	Height	Depth	Weight
TP-2	19"	5-1/4"	10"	30
TP-5	19"	5-1/4"	13"	40
TP-10	19"	5-1/4"	15"	51
TP-15	19"	5-1/4"	20"	72
TP-30	19"	7"	20"	100

TABLE 1-2

Mounting:	All units may be mounted on a standard 19" relay rack panel.
Terminals:	Front and rear-mounted terminals are incorporated which provide ac input, dc output and remote sensing. (For functions see Schematic, Figure A-1.)

1-10. APPLICABLE DOCUMENTS.

Design Control:	Behlman-Invar Drawing Numbers as follows:
TPA-2:	001A-0095
TPA-5:	002A-0095
TPA-10:	003A-0095
TPA-15:	006A-0095
TP-30:	009-0095

SECTION II

PRINCIPLES OF OPERATION AND INSTRUCTION

2-1. DESIGN OBJECTIVE.

The design parameters of the Model TPA Series power supply contribute to their operation in the following manner:

a. Provide a dc power supply fully regulated that is variable from 0 to 32v other than the TP-30 which is 0 to 36v dc, as specified in the electrical specifications. (See Paragraph 1-7.)

b. Provide high efficiency operation by allowing only a minimum of internal wattage dissipation regardless of output load conditions.

c. Provide fully rectified, filtered and stabilized voltage for the regulation circuitry, transformer section, filter section and Zener diode section.

d. Provide a remote sensing function, permitting the output voltage to be regulated from the voltage sensed at the load end. This feature ensures that the output voltage at the load remains constant. within the regulation specifications, with a nominal line drop.

2-2. CIRCUIT THEORY OF OPERATION.

Input ac is supplied from J1, Pins 2 and 3, through S1 and DS1 to T1 and T3, the auto and auxiliary transformers, respectively.

The ac from T1 passes through Fuse F1 to T2, the step-down power transformer of the raw dc section of the power supply. For the TP-2, the output of T1 is applied to the rectifier CR1 through CR4 and then filtered through the network of R41-1, R41-2, C1-1 and C1-2. For the TP-5, TP-10, TP-15, and TP-30, the same theory applies with the exception that R41-1 and R41-2 network is deleted.

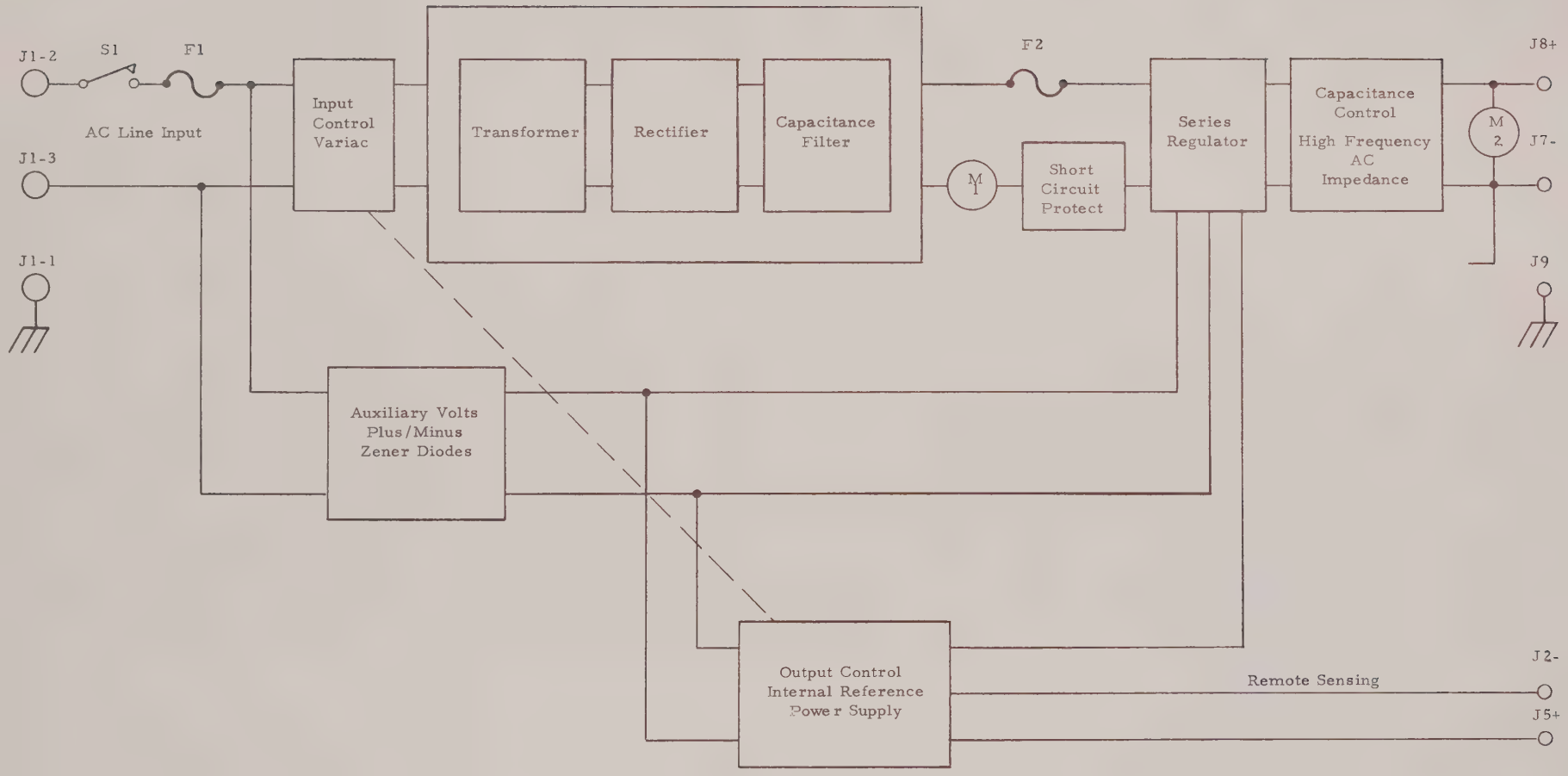

FIGURE 2-1. TP SERIES FUNCTIONAL BLOCK DIAGRAM

The raw dc is then fed through F2 being applied to the series regulator pass transistors Q10-1 and Q10-2, whose bases are driven by the power driver Q9 and the small signal Q8, whose bases are in turn being driven by the balanced amplifiers Q6 and Q7.

The power supply output voltage is sensed at the base of Q7 and compared with a very stable reference voltage developed across R27, the output coarse voltage control, and R26, the output fine voltage control.

2-3. INTERNAL REFERENCE SUPPLY.

The internal reference supply section, consisting in part by the transistors Q2, Q3, Q4 and Q5, and Zener reference diode Cr 12, is essentially in itself a small regulated dc supply, whose purpose is to furnish a highly regulated comparison voltage to the base of Q6.

2-4. AUXILIARY SUPPLY.

Raw dc being furnished to the internal reference supply (See Paragraph 2-3) is obtained from the auxiliary supply section and fed from Transformer T3 to the rectifiers CR5 through CR8, then passing through the filtering network of R1, R2, C2, and C3. Zener diode CR9 furnishes the minus output voltage and CR10 furnishes the plus output voltage for the auxiliary supply.

2-5. SHORT CIRCUIT PROTECTION.

The maximum output current adjust section and short circuit protection consist of Transistor Q1 and Potentiometer R17.

A reference voltage of approximately one volt is established at the emitter of Q1 by the diode CR11 and the dropping resistors R7 and R8. As the current increases through R17 a voltage drop occurs which is tied to the base of Q1 through the potentiometer R16. As this voltage reaches and exceeds the emitter reference voltages, Q1 is turned on. The collector of Q1 is tied through R11 to the base of the small signal driver Q8, thus when Q1 is turned on Q8's base is grounded and current decreases.

In order to obtain the current cutback feature of our short circuit protection the reference voltages of the emitter of Q1 is lowered as the output voltage drops in short circuit and requires less current through R17 to maintain cut-off in the pass transistor.

2-6. CONTROLS.

a. OUTPUT VOLTAGE COARSE, ganged mechanically with R7, R27, and T1, auto transformer, located on the front panel.

b. OUTPUT VOLTAGE FINE, for R26, located on the front panel.

c. MAXIMUM CURRENT ADJUST, for R17, located on the front panel.

d. J1, power input Jones plug, located on the rear of the chassis.

e. S1, toggle switch for ac line input, located on the front panel.

f. DS1, amber "AC ON" indicator light, located on the front panel.

g. M1, 0 to 3 ammeter, located on the front panel.

h. M2, 0 to 40v dc voltmeter, located on the front panel.

i. Plus/minus dc output, chassis ground, also plus/minus remote sense terminals. (For function see Schematic, Figure A-1.)

j. Plus/minus dc output terminals and chassis ground, located on the front panel. (For function see Schematic, Figure A-1.)

2-7. OPERATIONAL PROCEDURES.

a. CONNECT: AC line to J1.

b. ACTIVATE: S1 to the "ON" position.

c. MONITOR: DS1 for "ON" indication.

d. ADJUST: Fine and coarse output voltage controls for the desired voltage.

e. ADJUST: Maximum current control for the desired current flow.

f. MONITOR: M1 and M2 for the desired readings.

SECTION III
MAINTENANCE PROCEDURES

3-1. MAINTENANCE AND TROUBLE SHOOTING.

The power supply does not require any periodic maintenance other than cleaning to remove excessive dust and dirt. If it is necessary to replace components, use only first quality commercial components of values and types indicated. No selected components are used. When replacing components or trouble shooting, observe "warning" (See Warning Notice, Paragraph 1-6) since dangerous voltages may exist in the power supply. If it is ever necessary to replace the variable autotransformer or either of the two potentiometers connected to the variable autotransformer by means of the gear chain, the following check should be used to insure that the gearing is correct. With the coarse output voltage control turned completely counterclockwise, the variable autotransformer T1 and the potentiometers R7 and R27 should be positioned in the same manner.

3-2. TROUBLE SHOOTING PROCEDURES.

a.	SYMPTOM:	No output voltage.
	POSSIBLE CAUSE:	Fuse blown.
	REPAIR PROCEDURE:	Check for damaged rectifiers or shorted input capacitors or transformer, before replacing ac fuse. If dc fuse is blown, then check for possibility of overheating and short circuit. Remove short circuit.
b.	SYMPTOM:	Poor load regulation.
	POSSIBLE CAUSE:	Maximum output current adjust potentiometer set at too low a value.
	REPAIR PROCEDURE:	Set potentiometer to proper maximum current setting. This is about 20% higher than the desired maximum current.

c. SYMPTOM: Poor regulation and output cannot be reduced to zero by output voltage control.

POSSIBLE CAUSE: One of the series regulating transistors, Q10-1 or Q10-2 on the heatsink, or Q9, on the board next to the heatsink, or Q2, on the main component board, is shorted.

REPAIR PROCEDURE: Replace transistor. To determine which transistor is shorted, open the emitter of Q8. If the output voltage drops to zero (without load), transistor Q8 should be replaced.

d. SYMPTOM: Power transformer and variable autotransformer overheated.

POSSIBLE CAUSE: One or more of the rectifiers CR1 to CR4 are defective.

REPAIR PROCEDURE: Replace rectifier.

e. SYMPTOM: Output voltage floats erratically.

POSSIBLE CAUSE: Remote sensing jumpers not tightly connected, or, if remote sensing is being used, remote sensing leads not properly connected.

REPAIR PROCEDURE: Check sensing connections.

APPENDIX

Component	At Zero Voltage	At 30 Volt Output	
		Zero I	5 Amp I
C2	22	60	50
C6	69	69	68
C7	59	45	44
C8	60	65	63
R29	36	36	36

TEST VOLTAGE CHART TP-2

C2	22	60	50
CR9	56	56	56
CR10	56	56	56
CR11	0.7	0.7	0.7
C8	45	45	45

TEST VOLTAGE CHART TP-5

C1	13	60	45
CR9	56	56	56
CR10	56	56	56
R24	44	44	44
R27	36	36	36

TEST VOLTAGE CHART TP-10

C2	20	54	40
C6	80	84	69
C7	59	46	42
C8	58	62	58
R29	36	36	36
Q20-27	10 (at 1 volt)	12	6
Q10-17	10 (at 1 volt)	12	3

TEST VOLTAGE CHART TP-15

Component	Measurement Function	Required Indication	
		No Load	Load
C1	Plus to Minus	+60	+45
CR9/CR10	Anode to Cathode	-56 ± 10%	-56 ± 10%
R24	ACROSS	-44	-44
R27	ACROSS	-36	-36
Q3	Collector to +output	-56	-56
Q8	Collector to + output	-60	-60
Q3	Emitter to output	-45	-45

TEST VOLTAGE CHART TP-30

All measurements to be taken with a 1000 ohms per volt meter or better.

FIGURE A-2. TEST VOLTAGE CHARTS.

REVISIONS				
SYM.	ZONE	DESCRIPTION	DATE	APP.
E		REVISED & REDRAWN	10-20-60	
F		R41-1 & R41-2 WAS R39-1 & R39-2	10-31-60	
G	1-B	CHANGED PER E.O. NO. 52 (G1)	11/17/60	
	1-B	CHANGED RER E.O. NO. 55 (G2)		
	3-B	BLOWER REMOVED AND TRANSFORMER PINS REVISED (G3)		
H		CHNGED PER E.C.O NO 315	9-9-61	
I		CHANGED PER E.C.O. NO. 404	11-2-61	
K		CHANGED PER E.C.O. 411	11-15-61	

T1
F1 SB 2AMPS
T2
CR1-CR4 10J2
R41-1 1.5Ω 3W
R41-2 1.5Ω 3W
C1-1 3850μF 60V
C1-2 3850μF 60V
DS1 NE51
T3
CR5-CR8 F4
R1 200Ω 10W
R2 200Ω 10W
C2 250μF 150V
C3 250μF 150V
CR9 10MS6Z10
C4 250μF 150V
CR10 10MS6Z10
R5 1.2K 10W
R3 400Ω 10W
S1
J1 3 2 1 115V 60~ GRD
R7 300Ω 4W
F2 2AMPS
R8 .51Ω 1W
R10 33K
R11 330Ω
R13 180K
R14 33K
Q3 2N1547
Q2 2N652
R20 3.1K 3W
R21 10K
R23 150K
C7 .001 μF 600V
R24 3K 2W
C8 50μF 50V
Q4 2N652
Q5 2N652
MAXIMUM OUTPUT VOLTAGE
R19 15K
CR12 1N2622
R22 4.7K
R25 400Ω 3W
OUTPUT VOLTAGE FINE
R26 100Ω 4W
R27 1K 4W OUTPUT VOLTAGE COARSE
C9 150μF 50V
R31 4.7K
Q6 2N652
Q7 2N652
R33 20Ω 3W
C6 .004 μF 200V
Q1 2N652
R15 100Ω
CR11 F4
R9 1K
R12 10Ω
R16 100Ω 10W
R17 3Ω 25W
R18 1Ω 10W
MAXIMUM CURRENT ADJUST
M1 0-3 AMPS
C12 2000μF 6V
Q10-1 2N1547
R37-1 3Ω 2W
Q10-2 2N1547
R37-2 3Ω 2W
Q9 2N1547
R29 6.8K 2W
Q8 2N652
R28 18K 2W
R30 220K
R32 33K
R34 5K 3W
R35 33Ω
R36 33Ω
REMOTE SENSING TERMINALS
-OUTPUT
+OUTPUT
GRD
M2 0-40 VOLTS
C10-1 5000 μF 40V
C10-2 5000 μF 40V
C11 50μF 50V

DRAWING NO. 001-0099
SHEET 1 OF 1
REV. K

3. ALL RESISTORS 1/2 WATT ± 10 %. UNLESS OTHERWISE SPECIF.
2. T1, R7, & R27 ARE MECHANICALLY LINKED.
1. THIS DWG SUPPLIED FOR THE OPERATION & MAINTENANCE OF INVAR EQUIPMENT AND IS NOT TO BE OTHERWISE USED OR REPRODUCED WITHOUT THE WRITTEN CONSENT OF THE INVAR ELECTRONICS CORP.

NOTES: UNLESS OTHERWISE SPECIFIED

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ENGINEER			
APPROVED		SCALE NONE	DWG SIZE D

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